AD 727 688

TECHNICAL REPORT
71-54-FL

DEVELOPMENT OF A STABLE LEAVENING SYSTEM FOR BAKERY MIXES

by

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May 1971

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

U.S. ARMY MATERIEL COMMAND

Food Laboratory
FL-133

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

US Army Natick Laboratories
Natick, Massachusetts 01760

2a. REPORT SECURITY CLASSIFICATION: Unclassified

2b. GROUP

3. REPORT TITLE

Development of a Stable Leavening System for Bakery Mixes

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Anthony Umina, Nancy Kelley, Thomas Everson and Donald E. Westcott

6. REPORT DATE: 19 May 1971

7a. TOTAL NO. OF PAGES: 19

7b. NO. OF REFS: 2

8a. CONTRACT OR GRANT NO.

b. PROJECT NO. PE 728012.12

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S): 71- -133-FL

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

US Army Natick Laboratories
Natick, Massachusetts

13. ABSTRACT

In order to prolong the shelf life of a prepared bakery mix a leavening system was desired which would prevent the premature escape of carbon dioxide due to interaction with moisture in the product during prolonged high temperature storage. A variety of methods was tried which would provide a barrier between the sodium bicarbonate and the leavening acid, sodium aluminum phosphate, and available moisture in the mix. These included encapsulating the sodium bicarbonate particles with hydrophobic materials such as hydrogenated vegetable or animal oils. The shortening protected sodium bicarbonate method was developed into a two layered bakery mix, separating the sodium bicarbonate from the moisture containing ingredients of the mix. Physical separation of the sodium bicarbonate was also investigated by packaging the sodium bicarbonate in a moisture proof pouch from which it could be mixed with the remaining ingredients at the time of baking. It was found that both the physically separated and the shortening - protected sodium bicarbonate in a layered mix method were successful in preventing the premature escape of carbon dioxide.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Prevention	8		4			
Releasing	8		4			
Carbon dioxide	3		4			
Cake mix	1,5		1			
Separation			8			
Sodium bicarbonate			2,10			
Sodium aluminum phosphate			2			
Moisture			2			
Encapsulating			10			
Packaging			10			

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Security Classification

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AD ______________

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DEVELOPMENT OF A STABLE LEAVENING SYSTEM FOR BAKERY MIXES

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Foreword

With today's emphasis on decreasing the ratio of support troops to combat troops, prepared or partially prepared foods play a major part in the food supply of the Armed Forces.

Bakery mixes have long been a problem since the relatively short shelf life of commercial mixes (1 year or less) is not adequate for military purposes. The requirement for an hermetically sealed container for overseas use created an additional problem in that it did not provide for prematurely released leavening gasses to escape from the container as is the case with the commercial package. This premature release is compensated for in commercial packages by a 10 percent over-leavening which, after normal storage, is reduced to about 90 percent of the optimum. Leavening is still adequate to produce a good quality item.

This study was initiated to explore means of providing good quality, stable bakery mixes for use by the Armed Forces. After much experimentation the most practical system was found to be to separate the soda from the rest of the mix by the use of a flexible, moisture proof package. This expediency not only solved the problem of premature escape of leavening gas, but it provides a means for a simple altitude baking adjustment which mixes designed for world wide use should have.

In addition, the acid salt in contact with the other mix ingredients seems to perform a beneficial effect during storage resulting in extremely stable textural characteristics.

Specific formulations were developed for all of the bakery mixes included in Federal Specification N-B-35 so that uniform quality from one supplier to another can easily be maintained. Models for the development of the formulae were retail mixes of major commercial manufacturers. The project has thus assured the availability to the services of a wide variety of stable bakery mixes of high quality.

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Abstract

In order to prolong the shelf life of a prepared bakery mix a leavening system was desired which would prevent the premature escape of carbon dioxide due to interaction with moisture in the product during prolonged high temperature storage.

A variety of methods was tried which would provide a barrier between the sodium bicarbonate and the leavening acid, sodium aluminum phosphate, and available moisture in the mix. These included encapsulating the sodium bicarbonate particles with hydrophobic materials such as hydrogenated vegetable or animal oils. The shortening protected sodium bicarbonate method was developed into a two layered bakery mix, separating the sodium bicarbonate from the moisture containing ingredients of the mix. Physical separation of the sodium bicarbonate was also investigated by packaging the sodium bicarbonate in a moisture proof pouch from which it could be mixed with the remaining ingredients at the time of baking.

It was found that both the physically separated and the shortening-protected sodium bicarbonate in a layered mix method were successful in preventing the premature escape of carbon dioxide.

The work was performed under project 728012.12, Production Engineering.

Introduction

One of the factors leading to the breakdown of prepared bakery mixes is the premature formation of carbon dioxide due to interaction of the leavening system and available moisture in the product (1,2). This study was undertaken to prolong the shelf-life by preventing the premature formation of carbon dioxide. Most commercial cake mixes are packaged in paper containers or in materials permeable to carbon dioxide gas. This allows for the escape of carbon dioxide evolved in storage. These mixes are formulated with about a 10% excess of leavening with the knowledge that as time progresses this excess will be dissipated. Since a leavening variation of ± 10% from the optimum does not materially affect the product performance, this procedure has led to moderate success under commercial conditions of storage. High temperatures, high humidity or long storage times, however, often act to reduce the activity of the leavening to less than 90% of the optimum with the resultant loss of baking performance and quality.

The Federal specification for cake mixes, N-B-35, required some mixes to be hermetically sealed in cans which led to excessive internal pressure causing the cans either to explode or to develop minor pinholes through which the gases escape.

Experimental Methods

In order to prevent the premature escape of carbon dioxide, it was necessary to eliminate the interaction between the sodium bicarbonate and sodium aluminum phosphate of the leavening system by causing the sodium bicarbonate to be inaccessible to the available moisture in the product. This was approached by three methods: encapsulation, protective coating within a layered bakery mix, and physical isolation of the sodium bicarbonate.

1. To determine the efficiency of encapsulation, sodium bicarbonate samples were obtained which were coated with the following hydrophobic substances:

a. Non-emulsified hydrogenated vegetable oil with a Wiley melting point of 110 to 117° F. The hydrogenated oil and sodium bicarbonate were blended to obtain a composition of 5.3% sodium bicarbonate.

b. Hydrogenated animal and vegetable oils with added mono and diglycerides and propylene glycol monoesters (PGME). The mono and PGME contents were 5.0 - 6.0% and 8.0 - 8.5% respectively. Wiley melting point was approximately 98 to 105° F. The materials were blended to obtain a sodium bicarbonate content of 5.3%.

c. Aqueous solution of Methocel 60 HG, 50 CPS, hydroxypropyl methyl cellulose. The coating procedure was performed at the Wisconsin Alumni Research Foundation utilizing Wurster spray drying equipment. The operating conditions of the equipment and the coating application rates were as follows:

Inlet Temperature	180 - 200° F.
Outlet Temperature	75 - 80° F.
Atomizing Air	40 psi
Rate of Coating Application	20 ml/min

The coating process was continued as long as possible before agglomeration of the particles occurred, resulting in a maximum of 8-10% coating by weight.

d. Ethyl alcohol-water solution of Methocel 60 HG applied under the same conditions as described in (c).

A series of white cake mixes using the above treatments plus a control mix (e) with sodium bicarbonate packaged separately in a moisture proof pouch, were made according to Table I. The sugar, surfactants, shortening and coated sodium bicarbonate were creamed together until homogenous. For treatments (a) and (b) the hydrogenated oil coating on the sodium bicarbonate was considered to be the shortening for the mix. The remaining dry ingredients were blended with the creamed mixture on a Triumph mixer. The mix was hermetically sealed in number 10 cans (4 lbs. 12 oz/can) and stored at 40° F. and 100° F. Upon periodic withdrawals,

pressure was measured with a Jas. P. Marsh vacuum-pressure gauge. Positive pressure indicated a loss in leavening power. Specific volume, measured by rape seed displacement, and quality scores were determined on the finished cakes. The cake scoring card and instructions for rating are shown in Figures I and II.

The following procedure was used to reconstitute the cake mixes for evaluation:

a. 19 oz. of water, 70° F., was added to 4 lbs, 12 oz. dry cake mix and mixed for one minute on low speed on a Hobart mixer.

b. The bowl and beater were scraped down and the mixture was stirred for two minutes on medium speed.

c. 19 oz. of water, 70° F., was added to the mixture and mixed for one minute on low speed.

d. The bowl and beater were scraped and the mixture was stirred for two minutes on medium speed.

One pound of the cake batter was scaled into an eight inch diameter cake pan and baked at 350° F. for 30 minutes. After baking, the cakes were cooled for two hours in the pan before specific volumes and cake quality scores were determined.

2. The second method, protective coating within a layered bakery mix, involved creaming the sodium bicarbonate particles with the non-moisture containing ingredients of the mix, namely the sugar and as much shortening as would allow this phase to be handled easily. In a separate phase, the leavening acid, sodium aluminum phosphate, was combined with the remaining ingredients and dry blended in a Triumph mixer. These two phases were hermetically sealed in number 10 cans (5 lbs/can) as two distinct layers according to the formula in Table II and stored at 100° F. with a control mix of the same formula in which all of the ingredients were combined conventionally. Upon periodic withdrawals pressure generation was measured to indicate a loss in leavening power.

3. The third concept, physical isolation of the sodium bicarbonate, was developed into the method of separately packaging the leavening in a moisture proof pouch. After opening the can, the pouch is opened and its contents combined with the mix prior to the introduction of water. The following treatments were evaluated:

a. Control. Sodium bicarbonate plus sodium aluminum phosphate incorporated directly into the dry mix.

b. Sodium aluminum phosphate incorporated into the dry mix; sodium bicarbonate in pouch.

c. Sodium bicarbonate incorporated into the dry mix; sodium aluminum phosphate in pouch.

d. Sodium bicarbonate plus sodium aluminum phosphate in pouch.

The white cake formula shown in Table III was used for the above study. The sugar, shortening, and surfactants were creamed together until homogenous. The remaining dry ingredients were blended with the creamed mixture on a Triumph mixer. The leavening chemicals for the various treatments were packaged separately in moisture proof pouches comprised of a laminate of 3 mil polyethylene, 0.35 mil aluminum foil, and 0.5 mil Mylar, and placed on the surface of the mix in number 10 cans (5 lbs/can) which were subsequently hermetically sealed. The cans were stored at 40° F. and 100° F. and examined periodically for pressure generation to indicate a loss in leavening power.

Table I - White Cake Formula for Encapsulation
Method of Leavening Separation

Sugar	43.00%
Cake flour	41.40
Shortening	9.50
Nonfat dry milk	2.00
Dried egg albumen	1.50
Salt	0.75
Sodium aluminum phosphate	0.50
Soda	0.50
* Monoglycerides	0.40
* Sodium stearoyl-2-lactylate	0.40
Monocalcium phosphate	0.05
Total	100.00%

* These emulsifiers were omitted in sample B, since the shortening used to coat the soda contained emulsifiers.

Figure I - CAKE SCORING INSTRUCTIONS

FLAVOR:	Grade A	Desirable, full, well balanced, delicate flavor attributed to the product
	Grade B	Free from off flavor
	Substandard*. . . .	Off flavor (too sweet, stale, too strong)
VOLUME:	Taken by rape seed displacement 2 hours after finished cake is removed from the oven	
CRUMB TEXTURE:	Grade A	Velvety, tender, but not crumbly
	Grade B	Not crumbly nor excessively tough
	Substandard*. . . .	Crumbly or tough
GRAIN	Grade A	Even, round, small air cells, thin cell wall
	Grade B	No large air holes
	Substandard*. . . .	Uneven air cells, large air holes
MOISTNESS:	Grade A	Moist, light, good mouthfeel
	Grade B	Not dry or pasty
	Substandard*. . . .	Dry, soggy, or heavy
CRUST COLOR:	Grade A	Golden brown, not spotted
	Grade B	Slightly lighter or darker than golden brown
	Substandard	Off color
SHAPE:	Grade A	Even, rounded top
	Grade B	Slightly flat top
	Substandard	Depressed or peaked top
CRUST SURFACE:	Grade A	Even, smooth, no cracks
	Grade B	Slight cracks or bubbles
	Substandard	Jagged peaks, cracks, or large bubbles
CRUST TEXTURE:	Grade A	No evidence of being sticky or brittle
	Grade B	Slightly sticky or brittle
	Substandard	Grainy, sticky, or brittle
FINAL GRADING:	Grade A	93-100 points
	Grade B	83-92 points
	Substandard	Below 83 points

* Limiting Rule

Figure II - CAKE SCORE SHEET

Date:______________ Experiment Code #:______________ Cake Type:______________

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ATTRIBUTE	MAXIMUM SCORE	GRADING	SCORE	GRADE
Flavor	20 points	20-19 . . . . A 18-17 . . . . B Below 17. . . . Substandard*	____	____
Volume	15 points	3.20 . . . . .15. . . . A 3.00-3.19. .14. . . . B 2.99-2.90. .13 Substandard* 2.89-2.80. .12 " 2.79-2.70. .11 " 2.69-2.60. .10 "	____ ____	____ ____
Crumb Texture	15 points	15-14 . . . . A 13. . . . . B Below 13. . . . Substandard*	____	____
Grain	15 points	15-14 . . . . A 13. . . . . B Below 13. . . . Substandard*	____	____
Moistness	15 points	15-14 . . . . A 13. . . . . B Below 13. . . . Substandard*	____	____
Crust Color	5 points	5 . . . . A 4 . . . . B Below 4 . . . . Substandard	____	____
Shape	5 points	5 . . . . A 4 . . . . B Below 4 . . . . Substandard	____	____
Crust Surface	5 points	5 . . . . A 4 . . . . B Below . . . . . Substandard	____	____
Crust Texture	5 points	5 . . . . A 4 . . . . B Below 4 . . . . Substandard	____	____

(* Limiting Rule) Total Score . . . . ____

Final Grade . . . . ____

Table II - White Cake Formula for Layered Mix Method of Leavening Separation

Sugar	92.473%
Shortening	6.452
Soda	1.075
Total Phase I	100.000%
Cake flour	77.383%
Shortening	12.149
Non fat dry milk	3.738
Dried egg albumen	2.804
Salt	1.402
Sodium aluminum phosphate	0.935
Emulsifier	0.748
Sodium stearoyl-2-lactylate	0.747
Coated monocalcium phosphate	0.094
Total Phase II	100.000%
Fill of container:	
Phase I	46.50%
Phase II	53.50
Total Phase I and Phase II	100.00%

Table III - White Cake Formula for Physical Separation of Leavening through the Use of a Moisture Proof Pouch

Sugar	46.04%
Cake flour	38.20
Shortening	9.96
Nonfat dry milk	1.44
Sodium aluminum phosphate	0.79
Dried egg albumen	0.74
Sodium bicarbonate	0.74
Salt	0.74
Sorbitan monostearate	0.40
Hard mono and diglycerides	0.30
Plastic mono and diglycerides	0.30
Coated monocalcium phosphate	0.15
Polyoxyethylene sorbitan monostearate	0.20
Total	100.00%

Results and Discussion

Encapsulation of the sodium bicarbonate with various hydrophobic agents was unsuccessful in preventing premature carbon dioxide release (Table IV). Cake mixes containing sodium bicarbonate treated with both types of hydrogenated oils and the two types of methyl cellulose had entered advanced stages of carbon dioxide production (9-10 PSIG) by 3 months storage at 100° F. This loss in leavening power was reflected in the finished cakes from these mixes which had specific volumes below the specification minimum of 3.00 and substandard cake quality scores (Tables V and VI).

However, the control mixes provided with a separate pouch of sodium bicarbonate showed no pressure generation even after 12 months storage at 100° F. The finished cakes had a specific volume well above the minimum 3.00 and the quality scores were significantly higher than those received by cakes prepared from the treatment mixes.

Up to 12 months storage at 100° F., the layered mix method of protecting the sodium bicarbonate was successful in preventing the release of carbon dioxide as shown in Table VII. At this time, no pressure was generated in the test cans, while the control had an internal pressure of 6.8 PSIG. Cakes produced from test cans were of good eating quality with fine grain and texture and good specific volume.

As seen in Table VIII, the cake mixes packed with leavening pouches of varying components and stored at 100° F. for one year showed evidence of released carbon dioxide if the sodium bicarbonate was not separated from the mix ingredients. Under these conditions the control, treatment A, with both the sodium bicarbonate and sodium aluminum phosphate directly in the mix, showed the greatest amount of carbon dioxide generation, 14.5 lbs. Treatment C with the leavening acid packaged in a separate pouch, and treatment D with both the sodium bicarbonate and leavening acid packaged in a separate pouch showed pressure generation of 8 lbs. and 8.5 lbs. respectively. However, those cans with the sodium bicarbonate packaged in a separate pouch showed no carbon dioxide production after being stored one year at 100° F.

Table IV - Pressure Generation Using Encapsulated Sodium Bicarbonate

Treatments:

A. Non emulsified hydrogenated oil coating.

B. Emulsified hydrogenated oil coating.

C. Aqueous methocel coating.

D. ETOH - aqueous methocel coating.

E. Control. Sodium bicarbonate in a moisture proof pouch.

Storage time	Treatment				
40° F.	A	B	C	D	E
0 mos.	0.0	0.0	0.0	0.0	0.0 PSIG
3	1.5	1.0	1.0	1.0	0.0
6	1.0	0.5	0.0	0.5	0.0
9	2.0	1.5	1.0	1.0	0.0
12	0.9	0.5	0.5	1.5	0.0
100° F.	A	B	C	D	E
0 mos.	0.0	0.0	0.0	0.0	0.0 PSIG
3	9.0	10.0	10.0	10.0	0.0
6	9.0	6.0	10.0	8.0	0.0
9	8.0	10.0	8.0	7.0	0.0
12	10.0	1.0	3.5	5.0	0.0

Table V - Specific Volumes of Cakes Baked from Mixes Using Encapsulated Sodium Bicarbonate

Treatments:

A. Non emulsified hydrogenated oil coating.

B. Emulsified hydrogenated oil coating.

C. Aqueous methocel coating.

D. ETOH- aqueous methocel coating.

E. Control. Sodium bicarbonate in a moisture proof pouch.

Storage time	Treatment				
40° F.	A	B	C	D	E
0 mos.	2.84	3.00	2.98	2.63	3.08
3	2.82	3.32	3.32	3.06	3.29
6	3.69	4.01	4.14	4.07	3.84
9	3.38	3.77	3.72	3.64	4.04
12	2.62	3.30	2.80	2.87	3.34
100° F.	A	B	C	D	E
0 mos.	2.84	3.00	2.98	2.63	3.08
3	2.40	2.76	2.54	2.47	3.18
6	2.63	3.23	2.23	2.25	3.56
9	2.14	2.87	2.01	1.94	3.42
12	1.60	2.00	1.65	1.40	3.21

Table VI - Quality Scores of Cakes Baked from Mixes Using Encapsulated Sodium Bicarbonate

Treatments:

A. Non emulsified hydrogenated oil coating.

B. Emulsified hydrogenated oil coating.

C. Aqueous methocel coating.

D. ETOH - aqueous methocel coating.

E. Control. Sodium bicarbonate in a moisture proof pouch.

Storage time	Treatment				
40° F.	A	B	C	D	E
0 mos.	92	94	97	90	99
3	95	97	94	95	98
6	84	96	93	95	97
9	96	94	95	95	96
12	86	99	97	91	96
100° F.	A	B	C	D	E
0 mos.	92	94	97	90	99
3	79	78	85	79	99
6	64	91	54	59	98
9	71	79	74	69	97
12	55	55	45	45	81

Table VII - Pressure Generation Using Layered Mix Method of Leavening Separation

Storage Time 100° F.	Control	Treatment
0 mos.	0.0	0.0 PSIG
3	5.0	0.0
6	6.5	0.0
9	7.0	0.0
12	6.8	0.0

Table VIII - Pressure Generation Using the Moisture Proof Pouch Method of Leavening Separation

Treatments:

A. Control. Sodium aluminum phosphate and sodium bicarbonate in mix.

B. Sodium bicarbonate in separate packet.

C. Sodium aluminum phosphate in separate packet.

D. Sodium aluminum phosphate and sodium bicarbonate in separate packet.

Storage Time

40° F.	A	B	C	D
0 mos.	0.0	0.0	0.0	0.0 PSIG
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.5*
3	0.0	0.0	0.0	0.0
12	0.5	0.0	3.0	0.0

100° F.	A	B	C	D
0 mos.	0.0	0.0	0.0	0.0 PSIG
1	0.5	0.0	3.0	6.0*
2	6.0	0.5	4.0	8.5*
3	8.5	0.5	**	**
12	14.5	0.0	8.0	8.5*

* Pressure build up in can was due to gas production in pouch which was severe enough to rupture side seam or escape through a pinhole.

** Results not available.

Conclusion

A stable leavening system for bakery mixes capable of withstanding long term storage at elevated temperatures can be achieved by either of two methods. The sodium bicarbonate portion of the leavening can be incorporated with the sugar and part of the shortening content of the mix. The remaining ingredients of the mix, including the acid portion of the leavening system, can be dry blended into a separate second phase. These two phases can then be packaged as individual layers in a single container.

Alternatively, the sodium bicarbonate can be packaged separately in a moisture proof pouch to be placed on top of the other ingredients of the mix in its ultimate container. Before the introduction of water into the mix, the sodium bicarbonate packet is opened, and its contents dry blended with the other ingredients of the bakery mix. The advantage of this method is that the amount of sodium bicarbonate added to the mix can be reduced for high altitude baking. The current specification for cake mixes (N-B-35) reflects this system and product procured has been performing very successfully.

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